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Key issues related to the integrated planning and management of land use, ecosystems and freshwater development, use and protection, with special emphasis on the impact of the quantity and quality of shared waters of riparian States

Integrated water resources management — reconciling interests of water use, land use and ecosystems

Inter-sessional issue paper

Summary

At its first session, in 1999, the Committee on Energy and Natural Resources for Development decided to prepare for its second session an inter-sessional issue paper addressing key linkages and strategic issues related to an integrated approach to land use, ecosystems and freshwater resources. The work was entrusted to an open-ended ad hoc group of members, coordinated by M. Falkenmark (Sweden). The present paper provides a basis for discussions on how to support the input of the Commission on Sustainable Development to the 10-year review of the United Nations Conference on Environment and Development, to be held in 2002. The preparations were to build upon the results of a Stockholm International Water Institute/International Water Resources Association seminar on the theme "Towards upstream/downstream hydrosolidarity", held in Stockholm in August 1999. The present paper builds on the results of both that meeting and a Global Water Partnership seminar held in November 1999 in Stockholm on integrating ecological services into water resources management.

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The need to take an integrated approach in river basin management was stressed in chapter 18 of Agenda 21. As shown in the present paper, this should incorporate the deeply interwoven issues of water-dependent land use (including food production for the growing population), water use in many different societal sectors (for survival, health, energy production, income generation etc.) and crucial ecological services (chemical, such as dentrification; physical, such as enhancement of infiltration and groundwater recharge; and biological, such as pollination, seed dispersal, pest insect control, and fish and meat production).

The need for such an integrated approach, incorporating both land use and ecological services, was discussed at the two above-mentioned seminars. Their results have been incorporated as a basis for the present paper. Hydrosolidarity in an upstream/downstream context will have to include attention to both green water (water vapour flows) and blue water (liquid flow in aquifers and rivers); to land use, water use and ecosystems (terrestrial as well as aquatic); and to the need for reconciling conflicts of interests between water-impacting upstream activities and ecosystems and water-dependent downstream activities and ecosystems.

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I. Background

A. Input of the Commission on Sustainable Development to the 10-year review of the United Nations Conference on Environment and Development

1. Given world developments since the United Nations Conference on Environment and Development (UNCED), the input of the Commission on Sustainable Development to the 10-year review of the implementation of Agenda 21 will have to incorporate issues which have emerged since UNCED, in particular of experiences and results since the five-year review conducted in 1997.

2. The world is undergoing an extremely rapid change as regards humanity's relations to the freshwater resources on which socio-economic development and quality of life genuinely depend. Major driving forces are population growth, urbanization and industrialization. A key event in this context is the Second World Water Summit, held in the Hague in March 2000. Deep global concerns for the growing crisis were reflected in the World Water Vision and its accompanying Framework for Action, presented by the World Water Commission and the Global Water Partnership, respectively. The key concept in the follow-up will be water security through integrated water resources management.

3. The main message of the World Water Vision is that although much has been achieved, today's water crisis is already widespread. The provision of six times more water to society today compared with 100 years ago has had significant impacts on people and their environment. In that sense, the cup is half full. On the other hand, large deficiencies remain in terms of lack of sanitation, a large degree of undernourishment, widespread damage to natural ecosystems, heavy subsidies and sectorized management. That makes the cup half empty and means that it is imperative to take action, especially in view of the strong driving forces. The Framework for Action puts focus on the need to make water governance more effective by taking an integrated approach and putting integrated water resources management into practice. River basin management and transboundary agreements form essential components.

B. Need for an integrated land/water/ecosystem approach

4. Agenda 21, in chapter 18, stressed the need for taking an integrated approach to water. It is not fully clear, however, what should be integrated, whether different sectoral uses of water, quantity and quality, land use and water resources, upstream and downstream activities etc. In recent years, it has become increasingly clear that the conventional approaches to water resources, concentrating on liquid water (blue water) in rivers and aquifers and on sectoral allocation of water, are becoming insufficient. Also, the water in the soil that makes land productive and returns to the atmosphere as part of the plant production process (green water) has to be considered as well.

5. The relationship between land use and water was addressed in a report submitted to the first session of the Committee on the spatial planning of land and water resources (E/C.7/1998/5). That report was a follow-up to earlier Committee discussions on land/water linkages. The report stressed that land use and water resources are closely intertwined. Therefore, the sectoral approach of the past has to be avoided. Under Economic and Social Council resolution 1999/49, the report was to be made available as a background document on integrated land management to the eighth session of the Commission on Sustainable Development after some complementary work as identified at the first session of the Committee.

6. Development work has also taken place within the Global Water Partnership, under which integrated water resources management has the central focus. Studies have been made on how to include proper attention to land use and protection of ecosystems in integrated water resources management. As part of these efforts, a seminar was organized in November 1999 at the Beijer Institute of Ecological Economics in Stockholm, with a focus on the inclusion of ecological services in integrated water resources management. Since the results of the seminar are of interest also to the Committee, they have been incorporated as a basis for the present paper.

C. Upstream/downstream relations

7. In the prevailing conventional approach to water development and utilization in most if not all countries, more stress is laid on allocation between different sectors rather than upstream/downstream interdependency and interaction. However, in wise water resources management, upstream/downstream linkages have to be duly considered. Attention has to be paid to what happens to water quality after use since a degradation of quality may jeopardize development options and environmental sustainability downstream. Moreover, development opportunities and options of some countries or regions literally depend on a water source entering from another country upstream. At the same time, people in upstream areas have a legitimate claim on the basin resources within their sections of the basin.

8. There is obviously a need to discuss upstream/downstream relationships in two important aspects: (a) what are the water needs, the reasonable claims and the efficient and fair utilization of basin resources in the various parts of a basin, and (b) what kind of management system is required to deal with the threats of water quality degradation. The same principal problem is noticeable within river basins, whether in a national or international context. The difference is the added political dimension in the latter case. The Stockholm International Water Institute (SIWI) organized in August 1999 an international seminar on the theme "Towards upstream/downstream hydrosolidarity". Since they are of interest for the input of the Commission on Sustainable Development to the 10-year review of UNCED, the results are incorporated as a basis for the present paper. The present paper also draws on a report on national sovereignty and international watercourses prepared by Green Cross International (1999) and presented to the Second World Water Forum. The present paper will discuss, as a background to discussions at the second session of the Committee, what additional principles are needed to reach a level of water security that pays adequate attention to land use and ecological services in the river basin context, whether national or multinational.

II. Where do we start?

A. Water and land-use linkages

1. Land-use conversions have water consequences

9. One fundamental problem is that the dominating conventional approach to water resources has its focus on water itself in view of the direct services that it provides to society. What is often neglected is more indirect services, such as water-driven plant production in rain-fed agriculture, pasture and forestry (FAO, 2000). This neglect has its origin in the temperate zone. In tropical climates, however, the evaporative demand is high, with a strong influence on the amount of water consumed (evaporated) per ton of biomass produced. This has led to the introduction of green water, i.e. water vapour flows. The liquid water flows in rivers and aquifers is referred to as blue water (see fig. I).

10. Society benefits directly from both branches of the water cycle: from the green for biomass production (food, fibre, pasture, fuelwood, timber) and from the blue for water-dependent societal water uses (water supply, industry, irrigated agriculture, hydropower). It also benefits indirectly through a multitude of ecosystem services provided by both the green and the blue branches, to be further discussed below.

11. The reason that attention has to be paid also to green water flow is the close link between the green and blue branches of the water cycle. The link between vegetation and the vertical transport of water vapour first attracted wider general attention in the discussions around the climate change in the humid tropics in view of the possible influence from the clearing of tropical rainforests, with their considerable vapour flows.

12. Dry, low latitude countries with a warm or hot climate have come to realize the hard way that there is a close connection between the water vapour consumed in plant production and what remains of the rain to produce groundwater and river run-off. Australia suffers from large-scale water logging and salinization in response to the deforestation started by European immigrants. South Africa has even introduced a system of reforestation permits to be applied for by foresters with reforestation or afforestation in mind.

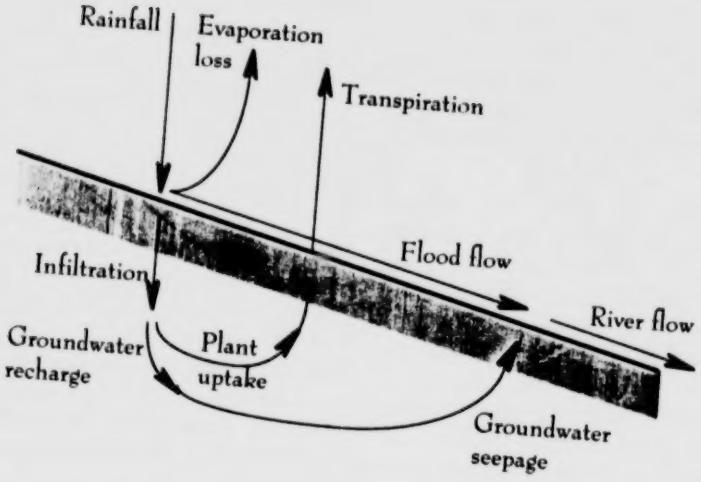

Figure I
Rainfall, on reaching the ground, divides into two main branches: the vertical branch of green water flow (water vapour) and the semi-horizontal branch of blue water flow (liquid water) passing through aquifers and rivers

13. There are important lessons to learn from Australia: one should by all means avoid waiting for the crisis to develop before action is taken (Beijer Institute, 2000). The salinity trauma of Australia, now threatening the productivity of some 25-30 per cent of the arable land of the country, shows that the price to be paid might be very high. The lesson from South Africa is equally useful: the alien vegetation with high water demand invading the whole country is reducing the rainwater surplus, leaving 10 per cent less of its blue water earlier available to the country. This insight has made it more and more evident that what has to be shared between those upstream and those downstream in a river basin is not only the water currently flowing in the river, as codified by the Convention on the Law of the Non-Navigational Uses of International Watercourses of 1997, but also the rainfall over the river basin.

14. The complementarity becomes evident when addressing the need for rapidly expanded food production in regions where most of the farming is rain-fed. Upgrading rain-fed agriculture will call for improving both the infiltrability and water holding capacity of the soils by soil conservation and the water uptake capacity of the roots by protection from dry spell-related plant damage (Rockström and Falkenmark, 2000). Also, forestry has a clear effect on blue water production in dry-climate tropical countries. Typically, deforestation on the one hand increases the run-off due to a decreased green water flow, and on the other impermeabilizes the soil, thereby reducing groundwater recharge and thus dry season river flow (Sandström, 1995). The result is dry season river depletion, combined with wet season floods. It has been suggested that the recent massive flooding reported from Yang tse Kiang in China may reflect a combination of both these factors.

15. Many poverty-stricken dry climate countries with rapid population growth today rely mainly on rain-fed agriculture. A crucial question is to what degree more green water flow will have to be appropriated to allow the additional food production. At the same time, a green water increase may be equivalent to a blue water decrease, i.e., a river and/or groundwater depletion. What this boils down to is no less than an existential issue for humanity's future.

2. Manipulations of landscape components are unavoidable

16. To satisfy societal needs for water, food, energy, goods and services, humans generally have to manipulate various landscape components (Falkenmark, 1997). Many manipulations are physical — soil permeability, slope, water courses, river flows, water tables etc. Others are chemical — on the one hand, agricultural chemicals leached to rivers and aquifers; on the other hand, waste products emitted to the atmosphere, reaching the ground as fall-out/wash-out, disposed onto the land, reaching rivers and aquifers through leaching, and emitted directly to water bodies.

17. Due to special properties of water, such manipulations will produce side effects, so-called "environmental effects". Some side effects are unavoidable, whereas others are avoidable (such as pollution from waste water). Side effects can occur as a result of:

(a) Changed water partitioning at the ground surface, influencing both the water flow down the catchment and the vapour flow to the atmosphere, and maybe even the vapour flow producing precipitation downwind;

(b) Water's function as carrier of solutes and silt, contributing to the transport of substances in the landscape and affecting water quality. The side effects manifest themselves in changes in water quality and quantity, with higher-order effects on water-dependent flora, fauna and biodiversity;

(c) Water cycle continuity generating chain effects from the atmosphere to the land and the terrestrial ecosystems, to groundwater, rivers and lakes and aquatic ecosystems, and to coastal waters and marine ecosystems.

18. Water quality problems tend to dominate in the temperate zone. River depletion may develop as a serious additional problem in low latitude regions with high evaporative demand. The fact that China's Yellow River in 1997 went empty seven months a year in its downstream part constitutes a serious reminder in this regard. In the past, water-generated side effects have often been considered as surprises and treated as unintended environmental impacts. With better understanding of the land/water linkages, land and water management should be seen as components of an

intentional ecohydrological landscape management, incorporating water uses, land uses and ecological services impacted by the necessary manipulations of land and water (Beijer Institute, 2000).

B. Water-ecosystem linkages

19. Ecosystems are genuinely water-dependent. Some types are rainwater-dependent, such as grasslands, forests and bogs; others are groundwater-dependent, such as dambos; and others are surface water-dependent, such as riparian wetlands and floodplains.

1. Ecological goods and services

20. Ecological goods and services are provided by a complex of nested ecological systems, driven by solar energy under the influence of hydrological and biogeochemical flows, and in interconnection with other systems (FAO, 2000). Examples of ecosystem services include:

(a) Chemical services, such as oxygenation of the atmosphere, carbon sequestration and denitrification;

(b) Physical services, such as enhancement of infiltration and soil permeability;

(c) Biological services, such as seed dispersal, pest insect control, fish production and meat production.

21. Freshwater, functioning as the bloodstream of the biosphere, plays a key role in the generation of ecosystem services, aquatic as well as terrestrial. But at the same time, "the work of nature" modifies water flows. Moreover, human activities alter the interactions between freshwater and ecosystem services. Freshwater goods supporting the population in a city include such goods as timber, fibre, paper, crops and seafood. Other services are involved in "treating" the output from the city, such as the reuse of phosphorus in agricultural areas, the sequestration of carbon dioxide in agricultural areas, biodegradation in inland water bodies, natural wetlands and forests, and denitrification in natural wetlands.

22. These goods and services need a certain area for production, referred to as the "ecological footprint" of the city. But water flows also have to be involved to make the production of ecological goods possible. While the perceived water support needed per urban inhabitant in the drainage basin of the Baltic Sea is only 440 cubic metres per year, the hidden water support is several orders of magnitude larger (Jansson et al., 1999).

2. Upstream versus downstream ecosystems

23. The linkages between water and ecosystems work in both directions (Beijer Institute, 2000). On the one hand, ecosystems tend to be water-impacting, sometimes contributing to redirections and changes in water flow and pathways and to quality transformations. On the other hand, water management/mismanagement have ecosystem consequences. Decisions on water use (e.g., irrigation, urban supply) or land use (deforestation, drainage of wetlands) will impact on water flows and thereby on species, habitats and ecosystems that are dependent on those flows. Societal activities are therefore deeply involved in producing ecological changes in both terrestrial and aquatic systems.

24. The ecological systems are hosted in a landscape and internally linked by flows of water in an upstream/downstream pattern. Accordingly, it is essential to distinguish between upstream ecosystems, such as forests or crop fields, which are involved in the rainwater divided between the evaporating part, the flood-flow part and the groundwater part, and downstream ecosystems, such as wetlands and water bodies, which are subject to water quality deterioration and river depletion.

3. Prerequisites for biodiversity protection

25. Habitats and ecosystems are always subject to change and are genuinely water-dependent. They may in fact be changed in many different ways — through rainfall changes, soil permeability changes, water pathway changes above and below ground, changes in water travel times, quantitative flow changes, seasonality changes, water table changes, changes in chemical composition etc. Protection of biodiversity is supported by an international convention. It has to be remembered that a certain species cannot be protected, however, unless its habitat, its food web and the capacity of the ecosystem to absorb disturbances is sustained (Beijer Institute, 2000). The species is generally at the end of long causal chains in which water, due to its many different functions in life-support systems on the planet, is involved at several of the component stages. Water is therefore a necessary

but not exclusive factor to pay attention to in ecosystem development and conservation. In the general debate of biodiversity and ecosystem conservation, much attention tends to be concentrated on the need to avoid direct, visible changes of wetlands and other ecosystems. However, attention must also be paid to indirect, invisible, creeping changes that are linked to water's movement and quality transformations as it moves through the catchment, above and below the ground surface.

4. Wetlands: a tricky concept in integrated water resources management

26. The concept "wetlands" tends to create misunderstandings among water professionals. The concept is clear from the biological perspective: biological behaviour is guided by water surplus and the presence of oxygen-rich and oxygen-poor conditions in parallel. "Wetlands", however, encompass a whole set of different types of landscape components. The water component may be of completely different origin (rainwater, groundwater, episodic floods, river water etc.). Three things are clear:

(a) Wetlands may develop in different parts of the catchment (coastal, riparian/flood plain, first order streams, peatlands, ponds etc.) and may therefore have rather different characteristics in terms of water origin;

(b) Protection of wetlands critically depends on a proper understanding of their hydrology, a fact well known to many wetland ecologists;

(c) Protection of wetlands is as much an issue of water quality as it is of water quantity. For instance, a sudden nutrient import will lead to significant ecological change.

5. Identification of determinants and threats

27. In order to be able to decide on ecosystem protection the relevant water-related determinants have to be clarified since they indicate the causal chain by which the ecosystems may be disturbed (Beijer Institute, 2000). These determinants include water flow, water pathways, flow seasonality, water table and water quality/chemical composition. They may be impacted by land use, by pollution load and by flow control and management measures. Figure II visualizes water-related causal chains between key ecosystem goods (biomass harvests) and services (biodiversity), at the target end, and human activities related to food, water and energy supply and the generation of income, at the disturbance end. Two types of land and water manipulations are important:

(a) On the one hand, direct manipulations of water flows and quality (flow control, water withdrawals);

(b) On the other hand, indirect manipulations of water flow through changes of land and vegetation, thereby influencing soil permeability and rainwater partitioning and consequently also water flow.

It goes without saying that a successful protection of a certain ecosystem, such as a wetland, evidently depends on enough understanding of its water-dependence and what particular threats it must be protected from. Similarly, to protect a certain species, the habitat of that species has to be protected against invisible, creeping changes linked to its water-dependence.

III. What is to be done? — Awareness of necessary trade-offs

28. Basically, the next generation will have to face the potential trade-off between freshwater for direct human needs, freshwater for the production of the additional food needed for a growing world population and the freshwater needed to support the ecosystems services needed for a sustainable society.

A. Landscape as an asset for development

29. The intimate linkages between water resources, water-dependent land use and water-dependent ecosystems discussed above makes it evident that sustainable socio-economic development will not be possible unless an integrated perspective is taken on all activities in a river basin, water-dependent as well as water-impacting. Freshwater flows, crop production and other terrestrial ecosystem services are interconnected and interdependent. As a consequence, land-use decisions are also water decisions. Consequently, the challenge is to manage our interconnected environmental assets in a fashion that secures their capacity to support societal development for a long time into the future (Beijer Institute, 2000). That will require conflicts of interest to be highlighted

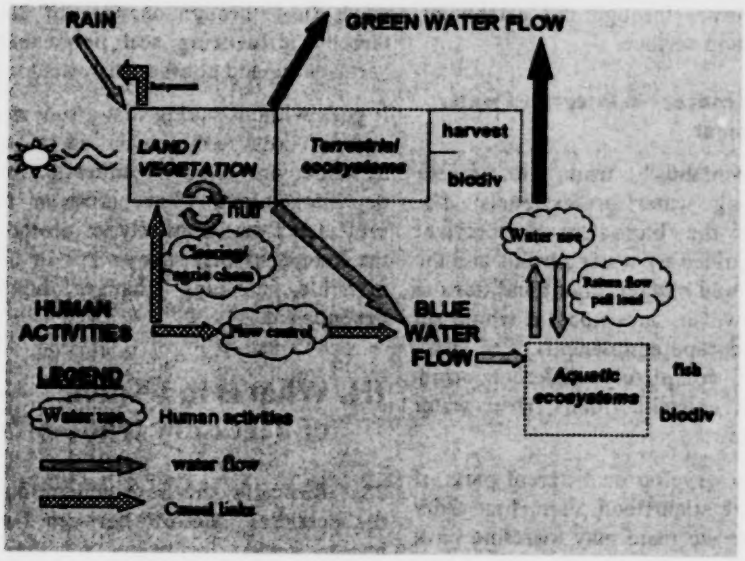

Figure II
Water-related causal chains between key ecosystem goods and services and human activities

in specific cases. Trade-offs that are to be made between the use of water and land in river basins must build on a proper understanding of the eco-hydrological landscape.

30. Key questions to be raised include: How much water needs to be left in the river and why? What pollutants have to be avoided and why? How can key interactions between systems can be secured? How much rainfall needs to be captured by terrestrial ecosystems to secure ecological services?

B. Fundamental upstream-downstream trade-offs

31. Basically, integrated water resources management, according to the definition used within the Global Water Partnership, involves coordinated development and management of water, land and related resources by maximizing economic and social welfare without compromising the sustainability of vital ecosystems.

32. Huge conceptual gaps between the water management profession and the environmental profession complicate the integrated approach (Falkenmark, 1999). Such conceptual differences have made it very difficult to arrive at a constructive dialogue. There is often a difference in the scale of approach: while the former have their focus on water in its role as landscape component, the latter often have their focus on individual species (a certain frog or butterfly) or biomes (natural reserves) that have to be protected. There is therefore a need for joint conceptual development of water professionals and ecological professionals so that they start to speak the same language and can enter into a true dialogue. Only in that way can the unavoidable trade-offs be properly addressed.

33. As already indicated, there is an important upstream/downstream dimension between land use, water and ecosystems and the various conflicts of interest involved, which have to be paid attention to in considering the unavoidable trade-offs. The upstream part of a catchment or river basin hosts a number of water-impacting activities: land use conversions, flow modifications and pollution load added. Together, they influence the river flow, seasonality and quality of the water flowing into the downstream part of the area. The downstream stakeholders are involved in a number of water-dependent activities: both direct water use for households and municipalities, industry, irrigated agriculture etc. and ecological services within riparian wetlands, aquatic ecosystems and coastal ecosystems (see fig. III).

IV. How is it to be done? — Towards upstream/downstream hydrosolidarity

34. Summing up the main points illustrated above, man's dependence on water is not merely a technical issue involving water supply and irrigation but a much broader issue since land use is not only water-dependent but also water-impacting. Therefore, upgraded water concepts are needed as a basis for conflict analysis and discussions. The river basin approach has to involve attention to direct and indirect freshwater services, as well as to water-related ecosystem services, terrestrial as well as aquatic. A fundamental challenge that will lead towards more sustainable socio-economic development is to find ways and means by which reconciliation can be developed between upstream and downstream activities, and between water interests, land-use interests and ecological interests. The starting point for such an approach has to be the rainfall over the river basin.

A. Land stewardship: a new task for the rural population

35. The above-mentioned Global Water Partnership seminar concluded that one way of seeing the integrated water resources management/ecological services linkages is to manage catchments as an asset that delivers a bundle of water and ecological goods and services (Beijer Institute, 2000). Some of these services work in synergy, while others are in conflict. Hence, intentional trade-offs need to be made, based on the view of human as embedded in the eco-hydrological landscape. From the conclusion that the land has to be seen as an asset for human activities follows the notion that landowners should be entrusted the task of managing natural resources as a whole and possibly be paid for that. That would involve a new role — land stewardship — for the rural population,

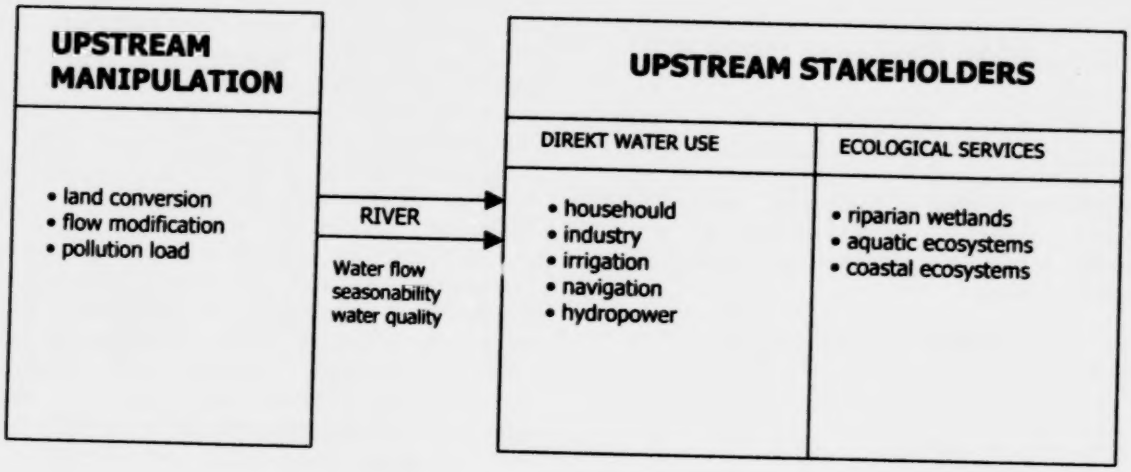

Figure III

Conflicting stakeholder interests in a river basin can be schematically systematized into water-impacting activities upstream, involving land and water manipulations and influencing water flow and quality, and water-dependent activities and systems downstream, influenced by water flow and quality characteristics

increasing their status. An interesting effort in this direction is the land-care movement in Australia. Ultimately, societal freshwater, land use and ecological services will have to be seen in a river basin perspective within a new hydrosolidarity thinking (SIWI, 1999). Upstream vegetation changes have flow consequences for downstream freshwater and ecological services. Upstream land-use changes and water uses involving the introduction of pollution loads will influence the quality of the water on which downstream activities and ecosystems depend. It is therefore essential to find ways to seek balance and compromises between upstream and downstream interests and ecosystems.

B. Mutual upstream/downstream considerations

36. The World Water Commission, in its report to the Second World Water Forum, stresses that in accepting integrated water resources management need as a basic principle, one has to recognize that some 260 rivers are shared between two or more countries and that ways have to be found to minimize conflicts of interest, advocating best use of the water at the basin level. In fact, the effective management of water could become a vehicle for collaboration as much as its absence could be a potential source of conflict.

37. As stressed by World Water Council's Sovereignty Committee (Green Cross International, 1999), recognition of the interdependence of people in itself constitutes a step towards conflict prevention. National sovereignty over internationally shared water is best expressed through cooperation and effective interdependence between peoples and different interest groups. The report stressed that in transboundary watercourses, both internal and external manifestations of sovereignty are relevant. People depending on the water in an international watercourse need to be assured access to and a role in the management of this water by their state authorities. These authorities therefore have a responsibility to maintain an acceptable level of water quality and water quantity for those further downstream, and not to develop in such a way that States further upstream will be hindered in their future water utilization plans. The Committee therefore stressed that it is a misconception that state sovereignty is incompatible with inter-state cooperation.

38. Upstreamers will, in other words, have to pay adequate attention to the ways in which their activities influence downstreamers. This is an issue of water ethics. Downstreamers have to look out for the way that upstream activities may influence their water-dependent activities. This is an issue of national security. Also, downstreamers will have to practise water ethics: they will have to adapt their expectations to what will be realistic in terms of the constraints that those expectations will imply for upstream activities. They will also have to provide motivation for the upstreamers to constrain their activities, both in terms of the pollution load introduced and the water-consuming biomass production, i.e., activities that would otherwise pollute and/or deplete the river on which the downstreamers and their aquatic ecosystems depend.

39. The Convention on the Law of the Non-Navigational Uses of International Watercourses, although not yet ratified by more than some 10 States, provides guidelines and principles for the process of regional agreements. Key concepts in the doctrine include "no appreciable harm to other riparians", and "equitable and reasonable use" of the precious resource. At the above-mentioned SIWI/IWRA seminar, Wouters (1999) stressed that by levelling the playing field for all stakeholders, at all levels, and permitting the consideration of all relevant factors, the rule of equitable use is a valuable instrument that serves to prevent adversial claims of hydro-sovereignty. Water law is relevant in defining, refining and applying the legal framework necessary to transform assertions of hydro-sovereignty into pacts of hydro-solidarity.

C. Three approaches to regional cooperation

40. According to the Sovereignty Committee report (Green Cross International, 1999), basin-wide cooperation is the optimal solution to the problem of managing an international basin and, as means of moving towards this goal, any progress towards States and peoples working together to achieve more effective water policy should be encouraged. The report also indicates a number of possible perspectives on regional cooperation:

(a) Cooperation as "allocation" — mainly for water sharing purposes but lacking a holistic vision of the basin and inflexible to change;

(b) Cooperation as "salvation" — in order to avoid absolute disaster, either in the form of conflict or environmental destruction;

(c) Cooperation as "opportunity" — to reach concrete mutual benefits, possibly also encouraging cooperative action on other regional matters.

D. Towards more sustainable agreements

41. In the long run, ethical rules will have to be developed which complement the Convention. With change of population, urbanization, industrialization, socio-economic development etc. the landscape and river flow is going to change. Land-use changes will produce creeping changes in water resources: upstream consumptive use by altered vegetation systems (crop production, larger afforestation/reforestation schemes etc.) may involve a continuous river depletion. This means that the flow in the river which was the base for the original agreement decreases with time, so that unforeseen allocation problems develop not only between sectors in a river stretch but also between upstreamers and downstreamers. These ethical rules have to recognize the interdependence of water, land use and ecosystem function and services, such as that a land-use decision is also a water decision. The Convention takes a dominantly blue water perspective. A question for the Committee to discuss is how land-use conversions, with their effects on river flow in tropical regions, could be incorporated in upstream/downstream agreements based on that doctrine. Such agreements have to be sustainable and stand the test of time, including land-use changes to support a rapidly growing population and their effects. The strong driving forces at work in developing countries, escalating their water needs and landscape manipulations, makes the concept of "no appreciable harm" to downstreamers particularly difficult to adhere to.

V. What should be done and by whom? — Implementation challenges

42. As shown in the present paper, the conventional approach to freshwater problems is insufficient and needs to be revised on three fronts, each of which is interlinked:

(a) Sectoral aspects: land use, household and industrial use, and environmental impacts;

(b) Upstream-downstream dimension, national and international;

(c) Generic aspect: blue water and green water.

43. There is a broad understanding of the interdependency between the three sectoral aspects for sustainable development and on the need for integrated planning when dealing with water.

44. The upstream-downstream dimension is also very important. The national Government can, more or less efficiently, solve problems internally by arbitrating conflictual situations and imposing some kinds of action. Hydro-solidarity becomes an obligation and not simply a part of water ethics. On the international level, the dimension upstream-downstream can lead to a real crisis. The issue of national security becomes an issue of international security.

45. As for the importance of the upstream-downstream dimension at the international level, the situation has to be remembered of some 40 countries in which the availability of freshwater is heavily dependent on international inflows from neighbouring countries (such as Egypt, Hungary, Bulgaria and Botswana for 90-95 per cent of blue water availability). In spite of the conclusion of 300 agreements on common waters since 1945 (Wolf, 1997), there are still numerous international water conflicts that have yet to be solved. The 1997 Convention, which deals with allocation, pollution and the ecosystem aspects of water uses, is designed to help settle conflicts.

46. The United Nations worked for more than 25 years, particularly within the International Law Commission, to achieve the adoption of the 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses. What has to be shared between those upstream and those downstream in a river basin, however, is not only the water currently

flowing in the river as codified by the Convention but also the rainfall over the river basin. As regards the sharing of rainfall, it would be useful to have some concrete principles and later a convention on that matter. The question "Who owns the rain?" has still to find an answer.

47. The green water role is complementary to the blue water. For some countries, the former is of paramount importance. But because of the mobility of water vapour and of the fact that some forests stretch over political borders, the question has also both national and international dimensions. It might be useful to draft a model law for countries to adopt (or to provide a basis for revising their national legislation), which takes into account agricultural use, domestic use and the environment, requiring the coordination between various ministries at the national level as well as land-use conversions and ecosystem protection.

48. The Committee may wish to discuss how and by whom:

(a) To make it possible to give the necessary attention to land/water/ecosystem linkages;

(b) To secure the implementation of such an approach.

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